Mariner Venus/Mercury 1973 Mission Support

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During March and April 1973, the DSN encountered problems in completing software development for DSS telemetry and command data handling. This impacted follow-on test plans and schedules. A large part of this article is devoted to the software problem and corrective action taken.

I. Planning Activities

A. NASA Support Plan

NASA Headquarters approval of the NASA Support Plan (NSP) for Mariner Venus/Mercury 1973 (MVM 73) has not been accomplished. NASA advises that the NSP will be returned to JPL for revision based on new resource allocations consistent with the current budget. The revised plan will be resubmitted for approval.

B. DSN Operations Plan

The approved version of the Network Operations Plan for MVM 73 was scheduled for completion in March 1973 to support the start of DSN testing in April 1973. However, the start of testing was delayed until May 1973 due to software development problems described in *Subsection III-B*. Therefore, the Network Operations Plan has been delayed accordingly, providing additional time for incorporating late changes.

C. DSN Support Team

The DSN Support Team for MVM 73 was to be discontinued at the end of February 1973 in favor of a DSN Test/Operations Team headed by the Network Operations Planning Engineer. However, the consensus was that the DSN Manager would continue the Support Team until major implementation difficulties are resolved and Project Ground Data System Tests are completed in June–July 1973.

D. Mission Design and Sequence Planning Support

The DSN has continued a high level of support to the Project for mission design and flight sequence planning. The Project's Mission Sequence Working Group has continued to revise the near-Earth, Venus, and Mercury sequences in preparation for a formal review on May 16, 1973. A key characteristic of the evolving mission sequence of particular interest to the DSN is the requirement for numerous, long ground command sequences. The DSN and Project are giving special attention to this characteristic. A set of ground command system rules, characteristics, and limitations will be developed for use in final sequence design and ground command operations.

In response to the Project's request, the DSN has evaluated capabilities to support Mercury encounter imaging data at 117 kbps containing a bit error rate as great as one in thirty. Although DSS analog recordings may be degraded, no difficulty is foreseen in real-time data handling and digital recording using the same configurations planned for Venus encounter. A one-month extension of the DSS 14-JPL 230-kbps wideband circuit

lease will be required. Means of reducing the bit error rate through improved DSS performance are being investigated (lower system temperature, listen only mode, use of high-performance ultracone). The use of real-time imaging data at 117 kbps versus 22 kbps will provide for full, rather than partial, photographic coverage of the visible portion of the planet Mercury.

Meetings have been held between the MVM 73, Pioneer and Viking Projects, and the DSN to discuss and resolve DSS resource schedule conflicts. Special attention was given to the October 1973–January 1974 period wherein MVM 73 launch/near-Earth TV calibrations, Pioneer 10 encounter and Viking Mars radar requirements exceeded available resources. With the exception of Viking Mars radar tracks in November 1973, resolutions which meet essential requirements were reached. Use of DSS 12 for MVM 73 near-Earth TV calibrations at 117 kbps in November 1973 in lieu of DSS 14 was proposed to resolve the Viking conflict. The DSN evaluated this and found it unfeasible in view of extensive equipment relocation required. Viking will consider alternative days. MVM 73 shifted near-Earth TV calibrations from DSS 14 to DSS 63 where possible to resolve other conflicts. These meetings have been very useful; future sessions are planned.

At the tenth Quarterly Review on March 29, 1973, the MVM 73 Project Manager announced a change in emphasis regarding the launch date. The launch date had been set at the first day of the launch period, October 16, 1973, with November 3, 1973 carried as the *preferred* launch date. Launch readiness is still considered to be October 15, 1973; however, November 3, 1973 is now set as the *planned* launch date.

II. Program Control

A. Interface Control Document

The MVM 73 Spacecraft/Mission Operations System/Tracking and Data System/Mission Control and Computing System Interface Control Document (ICD) has been recycled through the DSN to process comments from other Project Systems. All appendices have been returned to the Project for publication.

B. Telemetry/Command Data Software Verification Review

This review was to be conducted in late March 1973 following completion of DSS software verification tests. However, the review has been delayed until May 1973, due to software development problems described in *Subsection III-B-1*.

C. Project Quarterly Review

The DSN participated in the tenth Quarterly Review held at The Boeing Company, Seattle, on March 29–30, 1973. Problem areas and DSN–Spacecraft interface activities were emphasized. Included during the trip was DSN participation in the Science Steering Group meeting and in the Ad Hoc committee for spacecraft–DSN–MOS compatibility test planning.

III. Implementation Activities

A. GCF Status

Ground communications high-speed and wideband data terminal implementation for MVM 73 remains on schedule. However, GCF Engineering has been receiving and working requests for delays in shipment of equipment components from government and contract suppliers. Minor delays have been accommodated without impacting communications readiness schedules; however, a significant effort has been required to maintain acceptable schedules for DSS 14's 28.5-kbps and 230-kbps wideband implementation. A NASCOM request for delay in the Los Alamos Remote Information Center high-speed circuit implementation is unacceptable to the Project and is being worked. Agreement has been reached with NASCOM regarding training for DSN people on government-furnished wideband terminal equipment. NASCOM will provide this training at JPL in May 1973. Installation, maintenance, and operations instructions will be covered. Communications operators from local and overseas locations will participate.

B. DSS Status

Significant problems were encountered in the final phase of telemetry and command software development, precluding delivery of operational software on April 1, 1973 as planned. This has severely impacted follow-on activities, causing extensive reorganization of test plans and schedules. This was the DSN's first "red-flag" item for MVM 73. Priority effort is being given to its resolution. The remainder of this article's report on implementation will exclude other DSS subsystems and concentrate on the software problem.

1. Telemetry and Command Data Subsystem (TCD). As reported in the previous article, stand-alone tests for each TCD software module were completed in early

February 1973. However, as subsequent steps were taken to integrate and test modules in the Telemetry and Command Processor (TCP) assembly, serious problems were encountered both in module interfaces and in TCP core size limitations. Continuing attempts in February 1973 to complete the TCP software in accordance with the approved design were unsuccessful. The design, requiring one integrated program for all MVM 73 telemetry modes and command data handling, grossly exceeded the TCP 920 computer core capability. A redesign was necessary and accomplished.

On March 9, 1973, the TCD Software Development Project briefed the DSN and MVM 73 Project on the redesign and revised plan for completing operational software. The redesign's key characteristic involved separation of the one TCP program into three programs as follows: (1) M26E—handles low-rate uncoded telemetry, 8⅓ and 33⅓ bps, plus commanding; (2) M26B—handles medium-rate coded telemetry, 490 and 2450 bps, plus commanding; and (3) M64H—handles high-rate coded or uncoded telemetry, 7.35 kbps, 22.05 kbps, and 117 kbps in the Data Decoder Assembly plus commanding in the TCP.

This design resolved excessive requirements on TCP core. However, reloading of a different TCP program is required when the TCP is designated to handle rates other than those encompassed in the loaded software program. As a consequence of reloading, command activity would be terminated and any commands in the TCP stack would be eliminated. Originally, this was considered to be an acceptable operational limitation. The then known mission sequence was such that the spacecraft would not, under normal conditions, switch between medium/high rate and the low rate. For example, either 490 or 2450 bps would always be observed on the low-rate subcarrier giving an uninterrupted command capability at the TCP. Coincidentally, the Project Mission Sequence Working Group had determined that spacecraft data rate switches from 2450 to 33⅓ bps were required when the telecommunications link degraded during certain spacecraft maneuvers and at encounter (enter and exit occultation). Loss of command capability due to TCP reloading during these events is unacceptable. Action has been initiated to redesign the M26B to include the 33⅓-bps rate. Changing bit rates in the TCP between rates assigned to each program is done quickly by TCP type-in without disturbing command activities.

The following actions have been taken to complete the TCD software coding and acceptance testing on the shortest possible schedule. A revised schedule was agreed on; key milestones are given in Table 1. Preliminary acceptance tests were conducted in parallel with final development as separate programs were made available. This led to early identification and correction of anomalies which would preclude transfer of the software to operations. A formal accounting process for anomalies was set up to give traceability through problem observation, correction, reverification, acceptance, and closure. Anomalies are categorized to assign priority for corrective action. Cognizant programmers, system engineers, and cognizant operations engineers participate in this process. Daily meetings are held between these individuals to review each day's test results and to plan future activities. Daily status reports are written and distributed. Additional CTA 21 station time has been authorized to provide for two shifts per day plus weekend support for software checkout.

Formal acceptance tests were initiated according to the revised schedule. Out of 150 anomalies detected, 100 have been closed, 40 have been corrected but are waiting acceptance, and 10 are still being worked. Version 6 of the system tape resolves most of the known anomalies and was delivered for start of acceptance tests on April 30, 1973. This system tape will be used for Ground Data System tests in early May 1973. Preliminary interface engineering telemetry and command data flow tests were conducted between CTA 21 and the Mission Test Computer Facility (MTCF) on April 23, 24, and 25, 1973. System tape Version 5 was used for these tests and only one minor anomaly was observed in the DSS output. Many anomalies regarding the DSN internal monitor interfaces with the TCP existed on tape 5 but were not visible to Project. These anomalies are corrected in Version 6.

The above actions will continue until TCD software is formally transferred to DSN Operations. Test results indicate that remaining milestones will be met, providing well de-bugged software for support of future test and mission operations activities.

IV. Test and Training Activities

Training of the DSN Operations Control Team for MVM 73 was completed during this period. Included were lectures and video taping at the Goldstone Complex Training Facilities. Tapes have been shipped for use at overseas locations.

The Ad Hoc committee for planning spacecraft, DSN, and MOS compatibility testing during the thermal–vacuum testing at JPL in July 1973 has met and reached agreement on a test program.

The flight spacecraft will be at JPL for thermal–vacuum chamber tests in July 1973. The current schedule establishes 150 hours of available test time from July 20 to August 1, 1973. Spacecraft thermal tests have priority and are scheduled to utilize the first 100 hours for testing at three different Sun-level periods of about 30 hours each: (1) 1 Sun with 10-W and 15-W traveling-wave tube (TWT), (2) 2 Suns with 20-W TWT, and (3) 4.8 Suns with 20-W and 35-W TWT. During each of these test periods, there is a "quiet period" of about 10 hours each. All or a part of the quiet periods are assigned for DSN compatibility tests as follows:

(1) 1.0 Sun—8 hours between hour 12 and hour 20.

(2) 2 Suns—10 hours between hour 40 and hour 50.

(3) 4.8 Suns—8 hours between hour 72 and hour 80.

NOTE: All DSN tests, while the spacecraft is in the chamber, shall be constrained to maintain the given spacecraft power and thermal state.

In addition, the DSN has been assigned a "listen-only mode" period of 4 hours during the 4.8-Sun test period to observe the planned switch from the 20-W TWT to the 35-W TWT and to analyze spacecraft telemetry exercises while in the 35-W TWT mode. The listen-only period should occur between hour 82 and hour 86.

After completion of thermal–vacuum tests, the spacecraft will go through tear-down and reconfiguration for Spacecraft Test Complex (STC) tests. Following 48 hours of system readiness tests and 12 hours of Mission Operational System (MOS) tests, the DSN has been allocated an additional 12 hours for compatibility tests at ambient temperature.

CTA 21 support is required for all DSN and MOS test periods. If tests are conducted according to plan, CTA 21 staffing will be required for two weekends.

Table 1. TCD software coding and acceptance testing key milestones

Supervisor stand-alone development tests complete	March 12
Supervisor plus command development tests complete	March 18
Supervisor plus telemetry development tests complete	March 19
Start preliminary acceptance tests	March 21
Deliver M26E for acceptance tests	March 21
Deliver M26B for acceptance tests	March 27
Deliver M64H for acceptance tests	April 6
Start formal acceptance tests	April 7
Conduct preliminary TCD/MTCF data flow tests	April 23–25
Deliver software to DSS 12 and DSS 14 for test support	May 1
Support ground data system tests	May 3
Deliver software (latest version) to overseas DSS	May 15
Complete formal transfer of software to operations	June 15